Financial innovations and managerial incentive contracting

Saltuk Ozerturk *Department of Economics, Southern Methodist University*

Abstract. The top executives' demands for financial instruments that enable them to hedge the risk exposure in their compensation has increased drastically in the last decade. We analyse the implications of a manager's hedging ability for effort incentives. We show that if the manager's hedging opportunity is limited to a known fixed number of trading rounds with risk-neutral third parties, then the equilibrium effort is not affected at all. If the manager has the opportunity to hedge without committing to a last trading round, however, she hedges completely and no effort incentives can be sustained. Therefore, limiting the manager's opportunity to hedge to a fixed known number of trading rounds is crucial for sustaining incentives. JEL classification: G30, G32

Innovations financières et la contractualisation des incitations des gestionnaires. Au cours de la dernière décennie, la demande d'instruments financiers capables d'aider les cadres supérieurs des entreprises à protéger leur rémunération du facteur risque a crû dramatiquement. On analyse les implications de cette habileté du gestionnaire à se protéger sur les incitatifs à l'effort. On montre que si les possibilités de se protéger sont limitées à un nombre fixe et connu de rondes d'échange avec des tiers indifférents au risque, alors l'effort d'équilibre n'est pas du tout affecté. Si le gestionnaire a la possibilité de se protéger sans s'engager à une dernière ronde, il se protégera complètement et aucun incitatif à l'effort ne peut être soutenu. Donc, limiter la possibilité du gestionnaire à se protéger dans un nombre fixe et connu de rondes d'échange est crucial si l'on veut des incitatifs qui durent.

I am grateful to two anonymous referees of the journal for many useful comments. I would also like to thank Alberto Bisin, Bogachan Celen, Gerald Garvey, Charles Himmelberg, Li Jin, Levent Kockesen, Onur Ozgur, Santanu Roy, Kamal Saggi, Paolo Siconolfi and Marti Subrahmanyam for their comments on earlier versions of this paper. The usual disclaimer applies. Email: Ozerturk@mail.smu.edu

Canadian Journal of Economics / Revue canadienne d'Economique, Vol. 39, No. 2
May / mai 2006. Printed in Canada / Imprimé au Canada

0008-4085 / 06 / 434–454 / © Canadian Economics Association

1. Introduction

The median compensation of S&P 500 CEOs increased by approximately 150% from 1992 to 1998, with stock- and option-based compensation providing the largest share of gains. The 1990s witnessed a dramatic increase in the numbers of top executives receiving compensation in the form of company shares or options on the company shares.[1] During that decade, the top executives' demands for financial instruments that can reduce the risk exposure in their compensation also increased. An article in the *Economist* reports that the use of derivatives to eliminate managerial exposure to firm risk has become a business of hundred millions of dollars.[2] According to Bettis, Bizjak, and Lemmon (2001), there has been a huge increase in the development, sophistication, and use of strategies that enable corporate insiders to hedge their stock ownership positions in their firms.

The agency theory on managerial compensation contracts justifies the use of performance-based reward schemes by the need to align the shareholder-managerial interests.[3] Linking the manager's wealth to firm performance by using stock-based compensation gives the manager correct incentives to maximize shareholder value. However, it seems that the managers are able to trade in the financial markets and unilaterally adjust the risk exposure in their compensation. By engaging in hedging transactions with third parties, the managers can potentially reduce the sensitivity of their wealth to firm performance and undo the intended incentive effect of stock-based compensation. Alarmed by the possibility that high-ranking corporate insiders might use hedging instruments to undo their incentive contracts, some practitioners recommend firms to severely restrict or preclude the use of these instruments (Schizer 2000).

A somewhat controversial issue is the permissive attitude of firms towards managers in determining the extent and the timing of their hedging transactions. Bebchuk, Fried, and Walker (2002) and Bebchuk and Fried (2003) argue that firms take surprisingly few steps to prevent or regulate the financial market access of their executives: 'Executives are left free to hedge away the equity exposure and typically are permitted to choose the amount and timing of unwinding' (Bebchuk, Fried, and Walker 2002, 76). They further assert that the optimal contracting approach is quite at odds with the managers' apparent freedom to hedge away the risk in their compensation: if the manager can potentially undo the incentive effect of the contract, why would the optimal contract allow the manager to trade with a third party and alter the

1 According to an article in the *Financial Times* by Chris Giles on 5 February 2002, between 1992 and 1998 the base salary of an average CEO increased by 29%, the average bonus increased by 99% and the average value of options granted rose by 335%. Also see the *New York Times* article 'The outrage constraint' by Paul Krugman, 23 August 2002.

2 'Executive relief,' *Economist*, 3 April 1999, 64. See also the *Business Week* article, 'Undermining pay for performance,' January 2001, 70.

3 See Murphy (1999) for a comprehensive survey on executive compensation.

pay-performance sensitivity freely? An editorial in the *Economist* agrees with this assertion: 'Hedging is almost never prohibited ... Logically, boards should restrict and control the sale of bosses' shares' ('Taken for a ride,' 11 July 2002).

In this paper, we formally analyse the implications of the managers' hedging ability for incentive contracting. To this end, we extend the standard principal-agent setting and consider the possibility that the manager can trade with third parties and unilaterally alter her risk exposure once her compensation contract is set by the firm. In particular, we follow the empirically documented hedging practice by Bolster, Chance, and Rich (1996) and Bettis, Bizjak, and Lemmon (2001) and focus on a commonly observed type of managerial trading which is known as an *equity swap*. In an equity swap transaction, the manager promises the third party to pay the return on her company's stock, in exchange for the cash flows on another asset such as a risk-free security.

Our analysis addresses the following questions: (1) Does the manager completely undo the incentive contract when she can trade with third parties or does she face a trade-off when choosing her optimal hedge size? (2) How does the optimal pay-performance sensitivity compare with the case where the manager has no opportunity to hedge? (3) How does the equilibrium effort choice of the manager compare when she can and cannot hedge? Does allowing the manager to hedge the compensation contract undermine incentives completely?

We first consider a setting where the manager's hedging opportunity is limited: the manager can hedge by trading a fixed known number of rounds (or equivalently a single round). The main results for this case are as follows.

1. The manager does not undo her compensation contract completely. This result follows, since the manager faces a trade-off in her hedging decision. The terms of the hedging transaction depend on the incentives the manager retains, that is, what she does not hedge.
2. The ex ante equilibrium pay-performance sensitivity is higher compared with the case when manager can not hedge. As long as the manager does not hedge completely, the hedging ability implies that the principal has to worry less about insuring the manager (because she does it herself) and more about giving the manager incentives. Accordingly, the ex ante (prior to hedging) equilibrium pay-performance sensitivity increases. This result may explain why steeper incentive contracts and hedging instruments have appeared roughly simultaneously in the U.S. financial markets during the 1990s.[4]

4 Schizer (2000) points out to the simultaneous increase in the availability of derivative instruments for hedging and the growing importance of the executive stock options and other forms of equity based compensation: 'In the capital markets, the 1990s have been the decade of executive stock options and the derivatives market. Enormous option grants have raised executive pay to staggering new heights, *while intensifying its sensitivity to firm stock prices*. Growth of the derivatives market have been comparably dramatic ... Equity swaps, for instance, are relatively new instruments. Moreover, in recent years, finding a counterparty has become much easier' (442; italics added).

The above comparison applies to the initial compensation package prior to hedging. Another interesting and relevant comparison is the manager's effective share ownership measured by the unhedged shares, that is, the ex ante pay-performance sensitivity minus the hedge size. The post-hedging risk exposure of the manager is the same, compared with the case with no hedging ability, if the third parties trading with the manager are risk neutral. If third parties are risk averse, the manager's post-hedging share ownership is strictly lower, compared with the case with no hedging.

3. The manager's hedge affects the principal's problem of optimal effort inducement only when the third parties trading with the manager are risk averse. If the third parties are risk neutral, then the equilibrium effort is the same with or without hedging. This result follows because, with risk-neutral third parties, the manager's trades do not impose any externality on the principal's optimal contract problem, since the manager fully internalizes the risk-incentive trade-off of the principal. Therefore, the cost of inducing the agent to a certain effort level and hence the surplus as a function of the induced effort is the same with or without hedging.

   The analysis then considers a setting where the manager can engage in sequential bilateral hedging transactions without any restrictions to a last round of trade and shows the following.

4. Limiting the manager's opportunity to hedge to a fixed known number of trading rounds is crucial for sustaining incentives. With no restrictions to a known last round (non-exclusivity), the equilibrium effort is adversely affected. The only allocation that survives the opportunity of further trading after each round is the one that completely insures the manager. Therefore, incentives are completely undermined: the manager fully hedges and the lowest possible effort is implemented in equilibrium.

Our results indicate that if the manager is limited to trade a fixed known number of rounds, then her hedging ability does not affect the equilibrium effort implemented. Without any restrictions or commitment to a last round of trade, however, no incentives can be sustained. To deny the manager the ability to engage in infinite side trades, the compensation committee can implement a restriction that the manager can trade, say twice every year with advance permission from the committee. It is interesting to note that restricting the manager's trades is one of the suggestions made by Bebchuck et al. (2003) in their critique of the principal-agent model of executive compensation: 'One could adopt a variety of restrictions on the timing of sales without hindering the executive's ability to satisfy legitimate liquidity and diversification needs. For example, one could require that sales are carried out gradually over a specified period or one could require the executive to receive advance permission from the compensation committee before trading' (Bebchuck and Fried 2003, 80).

Related Literature: The most closely related paper to this paper is Bettis, Bizjak, and Lemmon (2001), which also addresses the managers' access to financial innovations. Bettis, Bizjak, and Lemmon (2001), however, do not provide a model that formally analyses the impact of managerial hedging on incentive contracting. The main conclusion of their empirical analysis is that the executives use financial innovations like zero cost collars and equity swaps (i) primarily for risk reduction purposes and (ii) as a substitute for insider selling when a large sale would be most likely to attract attention. Our paper contributes to this relatively new literature by formally analysing the determinants of the manager's demand for a financial innovation and how the access to that financial innovation changes the nature of the trade-off in incentive contracting.

Some recent papers also address the managers' ability to alter the risk in their compensation. A common theme in these papers is that the optimal compensation contract should take into account the risk averse manager's ex post incentives to diversify away the systematic risk (Ozerturk 2006; Garvey and Milbourn 2003; and Jin 2002) or substitute between systematic and firm-specific risk factors (Acharya and Bisin 2003). In contrast to this paper, these papers preclude the manager's ability and incentives to diversify the firm level risk by assumption. In practice, many of the managerial hedging instruments are focused on the firm-specific risk rather than the systematic risk. This is especially true in case of equity swaps and zero-cost collars, the two most common hedging instruments manager use (see Bettis, Bizjak, and Lemmon 2001, 348).

The paper is organized as follows. The next section describes the model. Section 3 formally lays out the contract problem. Section 4 presents the benchmark case with no hedging. Section 5 analyses the model with hedging and contains our results. Section 6 discusses the implications of the analysis and concludes. Proofs not presented in the text are contained in the appendix, where a more general framework is presented to illustrate the robustness of the results.

2. The model

We extend the standard principal-agent setting to incorporate for the possibility that the agent can trade with third parties after her compensation contract is set. The basic ingredients of the model are as follows:

Technology and preferences: An agent (the manager) runs a firm owned by a principal (the shareholder). The principal is risk neutral and maximizes the final firm value net of the manager's compensation. The manager has exponential preferences with a constant absolute risk aversion coefficient $a > 0$. The final value of the firm, X, is determined by the stochastic technology $X = e + \varepsilon$, where e is the costly and unobservable effort expended by the manager and ε is the stochastic component over which the manager has no control. For tractability, assume that the manager's cost of effort is given by $c(e) = ke^2/2$ with $k > 0$, a constant. Furthermore, we employ the standard normality assumption on the distribution of ε and assume that $\varepsilon \sim N(0, \Sigma)$.

Manager's compensation: Drawing on the optimality results in Holmstrom and Milgrom (1987), we restrict attention to linear compensation contracts.[5] In particular, the manager's compensation contract is described by a pair (F, s), where F is a fixed payment and s is the manager's share of the final firm value. Accordingly, the manager's compensation is given by $F + sX$. In what follows, we refer to s as the pay-performance sensitivity of the manager's compensation scheme.

Trading with third parties: We allow the manager to trade with third parties *before* she makes her effort choice.[6] Legal constraints and regulations that restrict the managers' ability to trade in the primary stock market as insiders are commonplace. However, our motivation is different from a standard insider trading model, where an informed manager trades in the stock of her own company. Instead, following the empirically documented hedging practice by Bolster, Chance, and Rich (1995) and Bettis, Bizjak, and Lemmon (2001), we allow for a commonly observed type of managerial trading, which is known as an equity (or diversification) swap.[7]

In an equity swap transaction, the manager agrees to pay the third party (usually an investment bank) the return from the firm's stock, and the third party pays the manager the return from an investment such as a fixed-income security (see Braddock 1997 for a complete discussion of how swaps are structured). Consider a transaction where the manager pays the third party αX in exchange for a fixed payment G. Notice that by engaging in a swap transaction, the manager can unilaterally alter the link between her compensation and shareholder wealth and *undo* her incentive contract: she can potentially set $\alpha = s$ and eliminate all the risk in her compensation.

The third parties are competitive and are willing to trade at zero profit. They also have exponential preferences with a constant absolute risk aversion coefficient $b > 0$. Furthermore, all third parties have rational expectations about the

5 The optimality of the linear sharing rule in Holmstrom and Milgrom (1987) depends critically on the constant absolute risk aversion utility function for the manager. Jin (2002) points out that in practice the sharing rule is often close to linear, because the convexity induced by the manager's stock options is negligible to the first order.

6 Fudenberg and Tirole (1990) considers an agency setting where the principal and the agent renegotiate the initial contract *after* the effort choice.

7 Bettis Bizjak, and Lemmon (2001) note that unlike open market trades (the standard insider trading practice), the managerial trading in equity swaps and other hedging instruments (like zero cost collars) are less likely to attract market scrutiny.

manager's subsequent effort choice given her eventual holdings of the company's shares and they perfectly observe the manager's initial contract with the firm.

We analyse two different trading environments. First, we impose the restriction that the manager can engage in only a fixed known number of trading rounds. In this setting, we characterize the manager's optimal hedge and effort decisions and the pay-performance sensitivity of the compensation contract. Then, in section 5.3 we remove this restriction and allow the manager to engage in hedging transactions without any restrictions to a known last trading round.

Before we formally lay out the contract problem, we summarize the sequence of events in our model. At stage 1, the shareholders (principal) offers the manager a compensation scheme (*F, s*). At stage 2, the manager trades with third parties. At stage 3, the manager chooses her effort. At stage 4, firm value is realized and manager consumes her portfolio wealth.

3. The contract problem

The principal optimally sets the compensation rule (*F,s*), taking into account the subsequent trading (α) and effort (e) choices of the manager. Given a compensation rule (*F, s*) and an action pair (α, e), the manager's wealth distribution is given by

$$W_m(\alpha, e; s, F) = [F + sX] + [G - \alpha X] - c(e). \tag{1}$$

With the normality assumption on the distribution of $\tilde{\varepsilon}$ and CARA preferences, the manager's expected utility can be written in the mean-variance form. The complete formulation of the contract problem is as follows:

$$\max_{(F,s)} (1 - s)E[X] - F, \qquad \text{subject to}$$
$$E[W_m(\alpha^*, e^*; s, F)] - (a/2)Var[W_m(\alpha^*, e^*; s, F)] \geq 0 \tag{2}$$

$$\alpha^* \in \arg\max\ E[W_m(\alpha, e^*; s, F)] - (a/2)Var[W_m(\alpha, e^*; s, F)] \tag{3}$$

$$e^* \in \arg\max\ E[W_m(\alpha^*, e; s, F)] - (a/2)Var[W_m(\alpha^*, e; s, F)]. \tag{4}$$

(2) is the manager's participation constraint, where we normalize the manager's reservation payoff to zero. Expressions (3) and (4) describe the manager's optimal trading and effort choices, respectively.

4. Benchmark with no hedging

It is useful to state the equilibrium pay-performance sensitivity and effort when there is no hedging possibility for the manager. Since the results for this case are well known, we keep this section brief. Given a contract (*F, s*), the manager chooses effort e to maximize $se - (ke^2)/2$, and hence she sets $e_{NH}(s) = s/k$. The principal chooses F and s to maximize $(1 - s)E[X] - F$, subject to the manager's effort choice $e_{NH}(s)$ and the manager's participation constraint, which holds as an equality in equilibrium:

$$se_{NH}(s) - c(e_{NH}(s)) + F - (a/2)\Sigma s^2 = 0. \tag{5}$$

Solving for F and using $e_{NH}(s) = s/k$, the principal's problem becomes

$$s^*_{NH} \in \arg\max\ (s/k) - (k/2)(s/k)^2 - (a/2)\Sigma s^2. \tag{6}$$

Therefore, the equilibrium pay-performance sensitivity and effort when there is no hedging ability are given by

$$s^*_{NH} = 1/(1 + ak\Sigma) \tag{7}$$

$$e^*_{NH} = 1/[k(1 + ak\Sigma)]. \tag{8}$$

5. Analysis

5.1. Effort choice

Suppose the manager receives a compensation contract (F, s) and then trades αX in exchange for G. The mean and the variance of her wealth distribution are given by $E[W_m] = F + (s - \alpha)e + G - c(e)$ and $\text{Var}\ [W_m] = (s - \alpha)^2\Sigma$. Accordingly, the manager's optimal effort choice that solves (4) is given by $e^*(s, \alpha) = (s - \alpha)/k$. If the manager sets $\alpha = s$ in the trading stage and eliminates all the uncertainty in her compensation, then she does not expend any effort and sets $e^* = 0$. Note, however, that the payment G she will receive in exchange for αX depends on her subsequent effort choice. We analyse the manager's choice of the hedge size α next.

5.2. Equilibrium with fixed known number of rounds

Consider, first, the case where the manager can trade either only once or a fixed known number of rounds. A key feature of the analysis with a single or fixed known number of rounds is that the trading opportunity available to the manager is exclusive so that the payment in the swap transaction depends on the quantity traded. Therefore, a single trading round and a fixed known number of rounds yield the same equilibrium allocation.

Suppose the manager offers to swap αX in exchange for a fixed payment $G(s, \alpha)$. All the third parties observe the manager's initial contract, and they have rational expectations about the manager's subsequent effort incentives. The manager chooses her hedge size α strategically, taking into account the effect of this choice on the payment schedule G. The equilibrium payment $G(s, \alpha)$ is determined by the following zero profit condition of the third party:

$$\alpha E[X \mid s, \alpha] - (b/2)\text{Var}[\alpha X] - G(s, \alpha) = 0, \tag{9}$$

which yields

$$G(s,\alpha) = \alpha e^{*}(s,\ \alpha) - (b/2)\alpha^2\Sigma. \tag{10}$$

The first term $\alpha e^*(s,\ \alpha)$ in the fee schedule represents the rational assessment by the third parties that, once the manager hedges α of her holdings, she sets $E\,[X/s,\ \alpha] = e^*(s,\ \alpha) = (s-\alpha)/k$. The second term $(b/2)\alpha^2\Sigma$ represents the adjustment (or discount) for risk. The manager chooses α to maximize

$$(s-\alpha)E[X \mid s,\alpha] + G(s,\alpha) + F - c(e^{*}(.)) - (a/2)(s-\alpha)^2\ \mathrm{Var}[X]. \tag{11}$$

When we substitute for $G(s,\ \alpha)$, $e^*(s,\ \alpha)$ and $c(e^*(.))$, an equivalent formulation of the manager's optimal hedging problem is to choose α to maximize

$$[(s-\alpha)^2/k] - (b/2)\alpha^2\Sigma + F - [(s-\alpha)^2/(2k)] - (a/2)(s-\alpha)^2\Sigma. \tag{12}$$

The following first order condition describes the manager's optimal hedge α^*:

$$\underbrace{\alpha^{*}\Sigma(s-\alpha^{*})}_{\text{marginal benefit of hedging}} \quad = \quad \underbrace{\frac{\alpha^{*}}{k} + b\Sigma\alpha^{*}}_{\text{marginal cost of hedging}}. \tag{13}$$

The manager faces a trade-off in her hedging decision for two reasons. One reason is the risk adjustment in the fee schedule: the term $b\Sigma\alpha^*$ stands for the *marginal cost of hedging due to the third-party risk aversion*. The second reason is that hedging decreases the manager's subsequent incentives to expend costly effort. When the manager increases α marginally, the third parties correctly assess the manager's subsequent lower effort choice, and thus $G(s,\ \alpha)$ goes down by $\alpha(\partial e^*(s,\ \alpha))/\partial\alpha) = \alpha/k$.

The first proposition reports the manager's optimal hedge size when her hedging opportunity is limited to a fixed known number of trading rounds.

PROPOSITION 1. *The optimal hedge size is given by* $\alpha^*(s) = ts$, *where*

$$t \equiv \frac{a\Sigma}{(a+b)\Sigma + (1/k)} \tag{14}$$

is the manager's optimal hedge ratio. The manager does not hedge completely. The manager's hedge α^* *is increasing in the firm level risk* Σ, *her risk aversion a, her pay-performance sensitivity s, and the cost of effort parameter k. It is decreasing in the third party risk aversion b.*

Proof. Solving (13) for α^* yields the expression for manager's hedge ratio t as described in (14). The comparative static results follow, since $(\partial\alpha^*/\partial s) = t > 0$ and t is increasing in Σ, a and k. ■

The manager's trade-off in choosing the hedge size can also be observed from the optimal hedge ratio in (14). Suppose third parties are risk neutral and set $b = 0$. The hedge ratio becomes

$$a\Sigma/[a\Sigma + (1/k)]. \tag{15}$$

$a\Sigma$ measures the importance of diversification for the manager; high risk aversion (a) and/or high level of firm risk (Σ) increases the demand for hedging. On the other hand, $1/k$ (inverse of the cost of effort parameter) measures the extent of the effort moral hazard problem that determines the cost of diversification. When k is very large, it is clear that with or without diversification, the manager's effort will be low anyway. Therefore, maintaining subsequent effort incentives to charge a higher G is less of an issue for the manager. In this case, the manager's hedge ratio approaches to 1 (full diversification). When k is low, the adverse effect of diversification on the subsequent effort incentives and hence on the payment G is more pronounced and the manager diversifies less.

Remark 1. What would happen if the manager was trying to hedge with the principal instead of third parties? This comparison relates our analysis to the renegotiation literature (see Holmstrom and Myerson 1993; Hart and Tirole 1988; Beaudry and Poitevin 1993, 1995). In this case, the manager's optimal hedge would be zero in equilibrium and hedging ability would have no effect. The reason is that the optimal contract without hedging trades off between inducing incentives and insuring the agent. In other words, it provides the agent the optimal insurance scheme from the point of view the principal. Any deviation from this insurance-incentive package (more insurance, less incentives) hurts the principal. Hence, if the agent tried to hedge with the principal, we would get the benchmark contract s^*_{NH} and $\alpha^* = 0$ in equilibrium. This is reminiscent of the result in renegotiation literature that interim renegotiation (which takes place before action is chosen) does not constrain the allocations attainable with full commitment (in our case no ability to hedge). The reason that we have a positive hedge in proposition 1 is because the hedge transaction between the third party and the manager does not take into account the principal's welfare.

5.2.1. Equilibrium pay-performance sensitivity

In order to fully characterize the impact of managerial hedging on incentive contracting, we now analyse how the principal responds to the manager's hedging ability in setting the optimal pay-performance sensitivity. The principal sets the linear contract (F,s) to maximize $(1 - s)E[X] - F$, subject to the manager's optimal hedge α^*, her optimal effort e^*, and the individual rationality constraint in (2). When we use the above expressions for α^* and e^*, the manager's individual rationality constraint becomes

$$se^* - (b/2)\Sigma(\alpha^*)^2 + F - c(e^*) - (a/2)\Sigma(s - \alpha^*)^2 \geq 0. \tag{16}$$

In equilibrium, this constraint holds as an equality. Solving for F and substituting for e^*, $c(e^*)$ and $\alpha^*(s) = ts$ (hedge ratio t is defined in (14)), one can state the principal's problem as

$$s_H^* \in \arg\max[(s - ts)/k] - [(s - ts)^2/(2k)] \\ - (b/2)(ts)^2\Sigma - (a/2)(s - ts)^2\Sigma. \qquad (17)$$

The first-order condition that describes the optimal s_H^* then follows as

$$1 - s_H^*[(1 + ak\Sigma)(1 - t) + bk\Sigma(t^2/(1 - t))] = 0. \qquad (18)$$

One can now solve for the equilibrium pay-performance sensitivity s_H^* by substituting for the equilibrium hedge ratio t.

PROPOSITION 2. *The equilibrium pay-performance sensitivity s_H^* is given by*

$$s_H^* = \frac{1 + bz}{1 + bz(1 + az)} \text{ where } z \equiv k\Sigma. \qquad (19)$$

Proof. See the appendix.

The following observations follow from proposition 2.

COROLLARY 3. *(i) The ex ante optimal pay-performance sensitivity s_H^* with hedging is strictly higher compared with the pay-performance sensitivity s_{NH}^* with no opportunity to hedge. (ii) If the third parties trading with the manager are risk neutral ($b = 0$), then $s_H^* = 1$.*

Proof. The comparison directly follows from

$$s_H^* = \frac{1 + bz}{1 + bz(1 + az)} > \frac{1}{1 + az} = s_{NH}^* \text{ where } z \equiv k\Sigma. \qquad (20)$$

Part (ii) follows from evaluating (19) at $b = 0$. ■

Therefore, the manager's hedging ability increases the ex ante equilibrium pay-performance sensitivity. We again discuss the intuition for the case when the third parties are risk neutral ($b = 0$) and hence $s_H^* = 1$. Recall that the manager's subsequent choice of the hedge size α fully takes into account the risk-incentive trade-off. The optimal strategy for the principal then is to set the pay-performance sensitivity as if the manager is risk neutral. In other words, the principal completely ignores any risk sharing considerations in the choice of the contract when the manager can hedge her risk exposure. The principal cares only for the incentive problem and lets the agent deal with the risk-incentive trade-off. Since incentive considerations call for higher pay-performance sensitivity, s is higher with hedging.

5.2.2. Equilibrium effort with hedging

We now compute the equilibrium effort implemented with hedging by directly substituting s_H^* and $\alpha^*(s_H^*)$ into $e^*(s, \alpha)$. First, note that

$$e^*(s_H^*, \alpha^*(s_H^*)) = \frac{s_H^* - \alpha^*(s_H^*)}{k} = \frac{(1-t)s_H^*}{k}. \tag{21}$$

Substituting for s_H^* from proposition 2, we obtain

$$e^* = \frac{(1-t)}{k} \times \frac{1+bz}{1+bz(1+az)}, \text{where } z \equiv k\Sigma. \tag{22}$$

Finally, substituting for the manager's optimal hedge ratio t described by (14) yields the equilibrium effort in terms of the exogenous parameters a, b, k, and Σ.

PROPOSITION 4. *The equilibrium effort implemented with hedging is given by*

$$e^* = \frac{1}{k}\left[\frac{1}{(a+b)z+1}\right] \times \frac{(1+bz)^2}{1+bz(1+az)}, \ \textit{where } z \equiv k\Sigma. \tag{23}$$

An important question is whether the manager's hedging ability adversely affects effort incentives. To make this comparison, note that $e^* = (s_H^* - \alpha^*(s_H^*))/k$ and $e_{NH}^* = s_{NH}^*/k$. Furthermore, for $b = 0$, it follows that

$$s_H^* - \alpha^*(s_H^*) = s_{NH}^*. \tag{24}$$

If the manager trades with risk-neutral third parties, the hedge transaction decreases her pay-performance sensitivity exactly to the level that the principal would offer if the manager had no hedging opportunities. Equation (24) also implies that for $b = 0$, effort levels are the same; that is, $e^* = e_{NH}^*$. The principal's effort inducement problem is the same with or without hedging if the third parties trading with the manager are risk neutral. In this case, since the third parties have the same preferences as the principal, the manager's hedge transaction does not impose any externality to the principal. If $b > 0$, however, one can show that (see the appendix)

$$\begin{aligned} s_H^* - \alpha^*(s_H^*) &= \left[\frac{1}{(a+b)z+1}\right] \times \frac{(1+bz)^2}{1+bz(1+az)} \\ &< s_{NH}^* = \frac{1}{az+1}. \end{aligned} \tag{25}$$

where $z \equiv k\Sigma$. Hence, the equilibrium effort is lower with hedging if third parties are risk averse.

PROPOSITION 5. *Suppose the manager's hedging opportunity is limited to a fixed number of trading rounds. If the third parties are risk neutral* ($b = 0$), *then* $e^* = e_{NH}^*$. *If the third parties are risk averse* ($b > 0$), *then* $e^* < e_{NH}^*$.

The intuition for the above result can also be illustrated directly. Consider the contracting problem between the principal and the manager when the manager is not allowed to hedge. The surplus as a function of the optimal effort is given by

$$e - c(e) - (a/2)\Sigma(ke)^2, \tag{26}$$

where the last term $(a/2)\Sigma(ke)^2$ is the risk premium that must be paid to the risk-averse manager to induce him to an effort level e by exposing her to a risk level $s = ke$. Now, consider the same problem when the manager can hedge by trading with third parties with risk-aversion coefficient $b > 0$. In this case, the surplus as a function of e is

$$e - c(e) - (a/2)\Sigma(ke)^2 - (b/2)\Sigma(\alpha^*)^2. \tag{27}$$

The additional last term $(b/2)\Sigma(\alpha^*)^2$ stands for the risk premium the manager has to pay to the risk-averse third party when she hedges an amount α^*. For this premium, she must be compensated by the principal ex ante. Given $\alpha^*(s) = ts$ and $s(1 - t) = ek$, one can translate this hedging cost to a function of effort as $(b/2)\Sigma(\alpha^*)^2 = (b/2)\Sigma k^2\lambda^2e^2$, where $\lambda \equiv t/(1 - t)$. This cost disappears when the manager does not have to pay a risk premium to her trading partners ($b = 0$). In this case, the principal's effort inducement problem becomes identical to the case without hedging. To summarize, when the manager's hedging opportunity is limited to a fixed known number of trading rounds, hedging ability affects the principal's effort inducement problem only when third parties are risk averse and demand a risk premium.

5.3. *Equilibrium with potentially infinite rounds*

In this section, we analyse the equilibrium of the model when the manager's hedging opportunity is not restricted to a known last round of trade. In particular, we now consider a trading environment where after any trading round further trading is possible. When the third parties anticipate that the manager might trade further after each round, the payment schedule they are willing to offer for the swap transaction is no longer characterized by (10). This is because after each round, the manager can engage in further hedge transactions that affect her subsequent effort choice. Therefore, further hedging dilutes the value of the previous claims she swapped. The third parties will then price the hedging transaction based on their conjecture of the manager's final holdings. This conjecture will be justified in equilibrium.

In order to characterize an equilibrium allocation that survives further trading possibilities, we rely and expand on Admati, Pfleiderer, and Zechner's (APZ, 1994) *globally stable allocation* equilibrium concept. This concept requires that although the manager can not commit to a last round of trade, once this allocation is reached, she will not have an incentive to trade away from it. In order to state formally the equilibrium concept, we first introduce some definitions. For convenience, let us define the manager's expected utility at some final allocation θ as

$$\Gamma(\theta) \equiv \theta e^*(s, s-\theta) - c(e^*(s, s-\theta)) - (a/2)\theta^2\Sigma. \tag{28}$$

Given the effort choice $e^*(s,\ s-\theta) = \theta/k$ and $c(e) = ke^2/2$, it follows that the manager's expected utility at a final allocation θ is given by

$$\Gamma(\theta) = \theta^2/(2k) - (a/2)\theta^2\Sigma. \tag{29}$$

We adopt a trading environment where the manager approaches a different third party in each trading round (*sequential bilateral trading*). This trading mechanism seems realistic, since swap agreements are essentially bilateral contracts. The equilibrium payment that a third party is willing to pay for a swap transaction δX is determined by the third party's conjecture on the manager's final holdings θ^* and the zero profit condition. This payment is given by

$$\begin{aligned} \delta P(\theta^*) &= \delta[e^*(s, s-\theta^*)] - (b/2)\delta^2\Sigma \\ &= \delta(\theta^*/k) - (b/2)\delta^2\Sigma. \end{aligned} \tag{30}$$

The conjecture θ^* for the manager's final allocation enters into the fee schedule through its effect on the subsequent effort choice $e^* = \theta^*/k$ of the manager. This choice determines the expected value of δX for the third party. The second term $(b/2)\delta^2\Sigma$ captures the risk discount of the third party for holding δX and it does not depend on θ^*. We now state formally the equilibrium concept.

DEFINITION. *(APZ 1994) An allocation θ^* is a globally stable equilibrium and survives further trading possibilities iff*

$$(i) \quad \theta^* \in \underset{\theta}{arg\ max}\, \Gamma(\theta) - \Gamma(\theta^*) + (\theta^* - \theta)P(\theta^*) \tag{31}$$

and (ii) for every initial allocation s such that $s \neq \theta^*$,

$$\Gamma(\theta^*) - \Gamma(s) + (s - \theta^*)P(\theta^*) > 0. \tag{32}$$

The first requirement says that when the third parties conjecture the manager's final holdings to be θ^* and they are willing to trade only at $P(\theta^*)$, the manager has no incentive to trade away from θ^*. This requirement implies that if the manager reaches θ^*, then the conjecture that this is her final holdings is justified. The second requirement says that, starting from any initial allocation s, if the third parties conjecture θ^* to be the final allocation, then trading from s to θ^* at price $P(\theta^*)$ is desirable for the manager.

We now characterize the equilibrium allocation. If θ^* is a globally stable equilibrium, then we must have

$$0 \in \underset{\delta}{\arg\max}\ \Gamma(\theta^* - \delta) + \delta P(\theta^*). \tag{33}$$

$\Gamma(\theta^* - \delta)$ is the manager's expected utility if she trades away from θ^* by swapping δX. In exchange, she will receive $\delta P(\theta^*)$, as described by the fee schedule in (30). In other words, at the globally stable equilibrium allocation, the manager's optimal hedge demand must be zero, given the conjecture θ^* and the corresponding price $P(\theta^*)$. Substituting for $\Gamma(.)$ and $\delta P(\theta^*)$, one can state this problem as

$$0 \in \arg\max_{\delta} (\theta^* - \delta)^2/(2k) - (a/2)(\theta^* - \delta)^2\Sigma + \delta(\theta^*/k) - (b/2)\delta^2\Sigma. \tag{34}$$

To ensure a maximum, we need $a\Sigma > (1/k)$, since then the above objective function is strictly concave in δ and the second-order condition is satisfied. Differentiating with respect to δ, we obtain the manager's optimal hedge demand at any round as a function the conjectured final allocation θ^* as

$$\delta(\theta^*) = \frac{a\theta^*\Sigma}{a\Sigma - (1/k) + b\Sigma}, \tag{35}$$

which implies that $\delta = 0$ only at $\theta^* = 0$. Therefore, the unique equilibrium allocation is

$$\theta^* = 0. \tag{36}$$

In other words, the manager hedges completely and $\alpha^{**}(s) = s$ for every s. The intuition is that the manager cannot commit not to dilute the claims of her previous trading partners. Given the price $P(\theta^*)$ she faces, her hedging demand is always positive for every conjectured allocation $\theta^* > 0$. This result establishes that, in the absence of any limits or commitment to a final trading round, the manager fully hedges any incentive contract s she receives. With unrestricted hedging opportunities, incentive contracting is completely undermined.

PROPOSITION 6. *Suppose that $a\Sigma > 1/k$. Then the unique globally stable equilibrium of the sequential bilateral trading game with potentially infinite rounds is that the manager hedges completely; that is, $\alpha^{**}(s) = s$ for every s and the unique equilibrium effort is $e^{**} = 0$.*

While considering the effect of manager's trades on the equilibrium effort, the exclusivity of the trading opportunity available to the manager (a fixed known number of rounds) hence is crucial. With potentially infinite trading rounds, the only allocation that survives further trading possibilities is the one that completely insures the manager. Since the manager obtains full insurance for any incentive contract offered, the principal cannot this time restore any incentives by appropriately designing the initial contract and the equilibrium effort is zero.

6. Implications and conclusion

In this section, we discuss some implications of our analysis and conclude.

IMPLICATION 1. *The use of private hedging instruments may not be necessarily detrimental to managerial incentives. However, the manager's hedging opportunities must be scrutinized by the firm.*

We illustrated that if the manager's hedging opportunity is limited and if the third parties trading with the manager are risk neutral, then the hedging ability does not undermine incentive contracting at all. In their empirical analysis of the implications of managerial hedging for incentive contracting, Bettis, Bizjak, and Lemmon (2001) address this issue as well. They examine the stock price performance subsequent to managerial hedging transactions. They do not find any statistically significant support for the hypothesis that the manager's hedging ability undermines effort incentives. Our analysis indicates, however, that the manager's hedging opportunities must be limited to hedge a known fixed number of rounds. As suggested by Bebchuck, (2003), this can be achieved by requiring the manager to carry out trades gradually and with advance permission from the compensation committee.

IMPLICATION 2. *Managers who experience large increases in the value of their equity positions demand hedging instruments more, i.e., an increase in the pay-performance sensitivity s increases the hedge size α.*

The above is a straightforward implication of the manager's risk reduction motive for using the hedging instruments. Bettis, Bizjak, and Lemmon (2001) find that the demand for hedging instruments is positively related to whether the firm recently went public. Going public decision provides a good experiment to test the determinants of the manager's hedging demand for two reasons: First, the insiders experience large increases in the value of their equity positions when the firm goes public. Our formal analysis predicts that this large increase would also increase the proportion of managerial wealth tied to the firm performance and hence should increase the demand for hedging. Second, insiders of firms that have recently gone public are often subject to lock-up provisions that prohibit them from immediately selling their shares (see Brav and Gompers 2003). As we mentioned before, using equity swaps and similar hedging instruments is a better option for the insiders than directly trading in the primary stock market, since it attracts less market scrutiny. Therefore, one would expect a sharp increase in the corporate insiders' demand for hedging instruments shortly after their firm goes public.

IMPLICATION 3. *The introduction of hedging instruments that enable the managers to privately reduce their risk exposure typically increases the equilibrium pay-performance sensitivity.*

As long as manager does not hedge completely (which undermines incentive contracting completely), the hedging ability actually increases the pay-performance sensitivity. The underlying economic reasoning for this prediction is as follows: When the manager has a hedging opportunity to alter her risk exposure unilaterally, the principal worries less about exposing the manager to firm specific risk. Recall that in a standard setting where the manager cannot hedge, the risk sharing consideration prevents the principal from increasing pay-performance sensitivity in the first place. When the agent can hedge, the principal's problem of designing an optimal compensation scheme to induce the agent the right incentives does not have to deal with insuring the agent (by exposing her to less risk). Since the manager subsequently changes her risk exposure according to her risk-return preferences, the principal can increase the pay-performance sensitivity. To the best of our knowledge, this implication of our analysis has not been empirically tested.

IMPLICATION 4. *Managers of companies with high stock price volatility demand hedging instruments more.*

This prediction follows from the manager's hedging choice α derived in proposition 1. Bettis, Bizjak, and Lemmon (2001) find supporting empirical evidence for this prediction. They document that insiders in firms with larger increases in stock return volatility are significantly more likely to engage in hedging transactions.

This paper has analysed the implications of managerial hedging on incentive contracting in a standard effort type moral hazard setting. For sustaining incentives, a key consideration is limiting the hedging opportunities of the manager to exclusive transactions so that the price of the hedge transaction depends on the quantity traded. Commitment to a final hedge round achieves this exclusivity, since the manager's trading partners infer the total quantity she trades and price the transaction accordingly. In this case, with third-party risk neutrality the same effort is implemented. If the manager can trade sequentially with no limits to a known last round, she hedges completely and no incentives can be sustained.

Appendix

A.1. Proof of proposition 2

Consider the first-order condition (18) that describes s_H^* in the text. Solving for s_H^* we get

$$s_H^* = 1/[(1 + ak\Sigma)(1 - t) + b\Sigma k(t^2/(1 - t))]. \tag{A1}$$

Now consider the denominator and denote $z \equiv k\Sigma$.

$$\begin{aligned}(1 + az)(1 - t) + bz(t^2/(1 - t)) &= 1 + az - t[(1 + az) - bzk(t/(1 - t))] \\ &= 1 + az - t[(1 + (a + b)z)/(1 + bz)] \\ &= 1 + [abz^2/(1 + bz)],\end{aligned}$$

where we used optimal hedge ratio t from proposition 1. Using the last expression, we have $s_H^* = (1 + bz)/(1 + bz(1 + az))$.

A.2. Proof of proposition 5

Again for expositional convenience let $z \equiv k\Sigma$. We want to show that for $b > 0$, we have $s_H^* - \alpha^*\left(s_H^*\right) < s_{NH}^*$ or

$$\left[\frac{1}{(a+b)z+1}\right] \times \frac{(1+bz)^2}{1+(bz)(1+az)} < \frac{1}{az+1}, \tag{A2}$$

which implies

$$\begin{aligned}(az+bz+1)(1+bz+abz^2) - (1+bz)^2(1+az) &> 0\\ az(1+bz+abz^2) - (bz+1)[1+bz+abz^2 - (1+bz)(1+az)] &> 0\\ az(1+bz+abz^2) - (bz+1)[az] &> 0\\ az(abz^2) &> 0,\end{aligned}$$

which proves the result.

A.3. A more general setting

We now sketch a more general framework than the linear contracting, normal distribution, and CARA setting analysed in the text. In this setting, we generalize the result that if the manager can commit to a final trading round when trading with *risk-neutral* third parties before the effort decision, then hedging ability does not affect the equilibrium effort implemented.

Let the final value of the firm $\tilde{x}$ be distributed with a probability density function $f(x, e)$, where $e \in [e_L, \infty)$ is the manager's costly unobservable effort. We assume that the expected firm value $\int xf(x, e)dx$ is increasing in e. The risk-neutral principal offers the manager a sharing rule $\phi(x)$, which specifies the manager's payment if the final firm value is $\tilde{x} = x$. Upon receiving $\phi(x)$, the manager can trade with risk-neutral third parties. In particular, we assume that the manager can swap a fraction $t \in [0,1]$ of her compensation in exchange for a fixed payment $G(t)$. We also assume that the manager can commit to a final trading round. Since the third parties are risk neutral, we have

$$G(t) = \int t\phi(x)f(x, e^*(t))dx. \tag{A3}$$

where $e^*(t)$ is the manager's subsequent optimal effort choice after hedging a fraction t of her compensation scheme. The manager's utility is separable in wealth and effort, that is, $u(w, e) = v(w) - c(e)$ where w is the manager's final wealth, $c(e)$, the disutility from effort is convex and increasing in e with $c(e_L) = 0$, and $v(.)$ is strictly concave. Accordingly, the contract problem is described as follows: The principal sets the compensation rule $\phi(x)$ to maximize $\int(x - \phi(x))\, f(x, e^*(t^*))dx$, subject to

$$\int v((1-t^*)\phi(x)+G(t^*))\,f(x,e^*)dx - c(e^*) \geq \bar{u} \tag{A4}$$

$$t^* \quad \in \quad \arg\max \quad \int v((1-t)\phi(x)+G(t))f(x,e^*(t))dx \tag{A5}$$

$$e^* \quad \in \quad \arg\max \int v((1-t^*)\phi(x)+G(t^*)f(x,e)dx - c(e). \tag{A6}$$

Expression (A4) is the manager's participation constraint. Expressions (A5) and (A6) describe the manager's optimal hedge and effort choices, respectively.

PROPOSITION 7. *If the fee schedule $G(t)$ satisfies $\partial G(t=1)/\partial t < 0$, then we have $t^* \in (0, 1)$; that is, the manager does not hedge completely.*

Proof. Let $e^*(t)$ denote the solution to the manager's effort problem. Clearly $e^*(t=1) = e_L$ and $e^*(t)$ is decreasing in t that is, if the manager hedges all of her compensation contract, she subsequently sets $e^* = e_L$. Furthermore, the more she hedges, the less incentives she has to expend effort. If the manager hedges completely, the corresponding fee she receives is given by $G(1) = \int\phi(x) f(x, e_L)dx \equiv \varepsilon$. Now consider the manager's problem of choosing the optimal hedge size in (52) and let $\Psi(t, x) \equiv v((1-t)\phi(x) + G(t))\,f(x, e^*(t))$. In order to prove the proposition, it suffices to show that

$$\int \left(\frac{\partial \Psi(t=1)}{\partial t}\right) dx < 0. \tag{A7}$$

Differentiating $\Psi(.)$ with respect to t and evaluating at $t = 1$, we obtain

$$\begin{aligned} \frac{\partial \Psi(t=1)}{\partial t} &= v'(\varepsilon)\left(-\phi(x) + \frac{\partial G(t=1)}{\partial t}\right) f(x, e_L) \\ &\quad + v(\varepsilon)\frac{\partial f(x,e)}{\partial e^*}\frac{\partial e^*}{\partial t} < 0. \end{aligned} \tag{A8}$$

Now we show that the equilibrium effort implemented is the same with or without hedging, when the manager can commit to a final trading round with risk-neutral third parties. Suppose the manager is not allowed to trade and for this case an optimal contract is $\phi^*(x)$ which implements an effort level e^*. Then the following first-order condition for effort choice must hold:

$$\int v(\phi^*(x))\frac{\partial f(x,e)}{\partial e}dx = c'(e^*). \tag{A8}$$

Now, suppose the manager is allowed to trade, and under the conditions of proposition 9 she hedges a fraction $t^* \in (0, 1)$ of her compensation scheme in exchange for $G(t^*)$. Let us define

$$\phi^{**}(x) \equiv \frac{\phi^*(x) - G(t^*)}{1 - t^*}. \tag{A9}$$

If the principal offers $\phi^{**}(x)$ and the manager hedges a fraction t^* of $\phi^{**}(x)$, her choice of effort must satisfy

$$\begin{aligned}\int v(\phi^{**}(x)(1 - t^*) + G(t^*)) \frac{\partial f(x, e)}{\partial e} dx \\ &= \int v(\phi^*(x)) \frac{\partial f(x, e)}{\partial e} dx \\ &= c'(e).\end{aligned} \tag{A10}$$

$\phi^{**}(x)$ induces the same effort that would be implemented without hedging. Furthermore, $\phi^{**}(x)$ satisfies the manager's participation constraint as an equality:

$$\begin{aligned}\int v(\phi^{**}(x)(1 - t^*) + G(t^*)) f(x, e^*) dx - c(e^*) \\ &= \int v(\phi^*(x)) f(x, e^*) dx - c(e^*) = \bar{u},\end{aligned} \tag{A11}$$

which follows, since $\phi^*(x)$ is optimal by definition and both $\phi^{**}(x)$ and $\phi^*(x)$ implement the same effort e^*. Finally, we need to show that implementing e^* by offering $\phi^{**}(x)$ is indeed optimal for the principal. The surplus from implementing a certain effort e is given by $\int xf(x, e)dx - c(e)$ minus the risk premium that must be paid to the risk-averse manager to implement e. With or without hedging, the manager's ex ante expected utility from implementing e^* is given by $\int v(\phi^*(x))f(x, e^*)dx - c(e^*)$. Therefore, the risk premium that must be paid to the risk-averse manager to implement e^* is the same in both cases. Consequently, implementing e^* by offering $\phi^{**}(x)$ is optimal for the principal.

References

Acharya, V., and A. Bisin (2003) 'Managerial hedging and incentive compensation in stock market economies,' mimeo, New York University

Admati, A., P. Pfleiderer, and J. Zechner (1994) 'Large shareholder activism, risk sharing and financial market equilibrium,' *Journal of Political Economy* 102, 1097–130

Beaudry, P., and M. Poitevin (1993) 'Signaling and renegotiation in contractual relationships,' *Econometrica* 61, 745–82

— (1995) 'Contract renegotiation: a simple framework and implications for organization theory,' *Canadian Journal of Economics* 28, 302–35

Bebchuk, L.A., and Jesse M. Fried (2003) 'Executive compensation as an agency problem,' *Journal of Economic Perspectives* 17, 71–92
Bebchuk, L.A., Jesse M. Fried, and David I. Walker (2002) 'Managerial power and rent extraction in the design of executive compensation,' *University of Chicago Law Review* 69, 751–846
Bettis, J. Carr, John M. Bizjak, and Micheal L. Lemmon (2001) 'Managerial ownership, incentive contracting and the use of zero cost collars and equity swaps by corporate insiders,' *Journal of Financial and Quantitative Analysis* 38, 345–70
Bolster, P., D. Chance, and D. Rich (1996) 'Executive equity swaps and corporate insider holdings,' *Financial Management* 25, 14–24
Braddock, J. (1997) *Derivatives Demystified: Using Structured Financial Products'* (New York: John Wiley)
Brav, A., and Paul Gompers (2003) 'The role of lockups in initial public offerings,' *Review of Financial Studies* 16, 1–29
Fudenberg, D., and J. Tirole (1990) 'Moral hazard and renegotiation in agency contracts,' *Econometrica* 58, 1279–319
Garvey, G., and T. Milbourn (2003) 'Incentive compensation when executives can hedge the market: evidence of relative performance evaluation in the cross-section,' *Journal of Finance* 58, 1557–82
Hart, O., and J. Tirole (1988) 'Contract renegotiation and coasian dynamics,' *Review of Economic Studies* 55, 509–40
Holmstrom, B., and R. Myerson (1983) 'Efficient and durable decision rules with incomplete information,' *Econometrica* 51, 1799–819
Holmstrom, B., and Paul Milgrom (1987) 'Aggregation and linearity in the provision of intertemporal incentives,' *Econometrica* 55, 303–28
Jin, L. (2002) 'CEO compensation, diversification and incentives,' *Journal of Financial Economics* 66, 29–63
Murphy, K. (1999) 'Executive compensation,' in *Handbook of Labor Economics*. Vol. 3. ed. O. Ashenfelter and D. Card (Amsterdam: North-Holland)
Ozerturk, S. (2006) 'Managerial risk reduction, incentives and firm value,' *Economic Theory* 27, 523–35
Schizer, D. (2000) 'Executives and hedging: the fragile foundations of incentive compatibility,' *Columbia Law Review* 100, 440–504